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Case Study: Disaggregating Interval Data to Identify Discrete Building Loads

Method 1: Load Identification with Traditional Pulse Collection

With conventional pulse collection equipment, the ability to identify the magnitude of individual loads with interval pulse data from the main building meter (and minimal knowledge of the building) is dependent upon (1) the ratio of the "pulse rate per time interval" to the "pulse rate" and (2) the ratio of "individual loads" that are desirable to identify to the "building load".

The "pulse rate per time interval" is identified as the quantity of pulses recorded per time interval (1 minute, 5 minute, 15 minute, etc.). Higher ratios of "pulse rate per time interval" to the "pulse rate" result in a greater ability to identify individual building loads. Due to the tendency of loads to cycle on/off at different points in a time interval, evaluating multiple adjacent time intervals may optimize the identification of individual loads.

Example – Low pulse rate per time interval vs. pulse rate

Consider a building electric meter recording 3 pulses per minute and a pulse factor of 0.096 kWh per pulse. This appears to be a load of 17.25 kW but if the load is slightly less than 17.25 kW, eventually there will be a time period recording only 2 pulses and it appears the load dropped to 11.5 kW, but it has actually been a steady load that is slightly less than 17.25 kW. The ratio of the "pulse rate per time interval" to the "pulse rate" = 31.25/1 for this example.

Example – High pulse rate per time interval vs. pulse rate

Consider the same building with a meter recording 30 pulses per minute and a pulse factor of 0.0096 kWh per pulse. The same load that is slightly less than 17.25 kW will eventually only record 29 pulses, and it appears there was a load reduction of 0.5 kW in one interval. This interpretation is not 100% accurate, but it is accurate enough to *disaggregate and identify individual loads*. The ratio of the "pulse rate per time interval" to the "pulse rate" is 3,125/1 for this example.

City Hall Traditional Load Profile with distinct load

At Boston City Hall there is approximately a 200 kW cooling load observed turning on when looking at the July 1st profile at 11:00am. On July 23rd a 200 kW cooling load is observed turning off at 12:00pm. The pulse factor for the electric meter is 0.03 kWh per pulse and the pulses per 5 minute time period are approximately 6,000. This ~ 10% change in the building load takes place across two-adjacent 5 minute time intervals. The kW change spread across 2-adjacent time intervals is consistent with the time delay used to stage the chiller compressor on separately from the condenser and evaporator pumps. The ratio of the "pulse rate per time interval" to the "pulse rate" is 200,000/1 for this example.

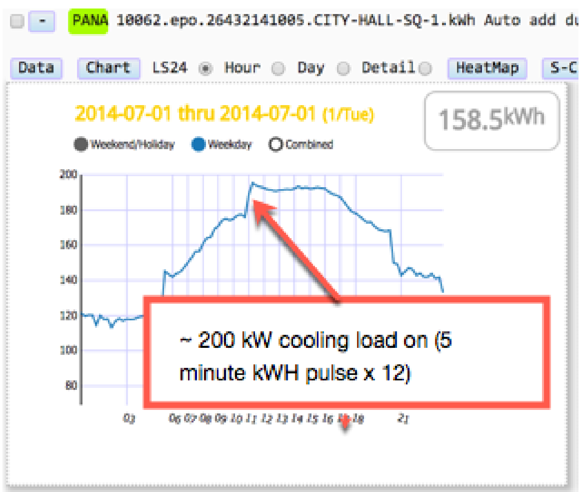

Figure 1. Discrete ~200kW load turning on.

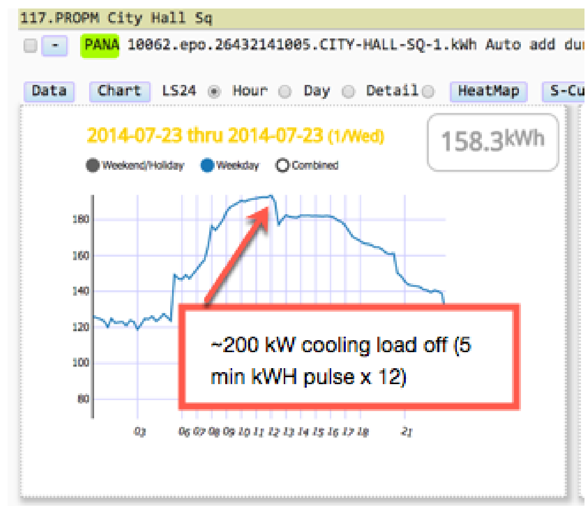

Figure 2. Discrete ~200kW load turning off.

Benefit of Including Equipment Schedules to Disaggregate Loads

Additional information about individual loads is revealed from the main electric meter pulse data when equipment scheduling is known. As example, in a school where all of the lights and HVAC equipment is turned on at the same time each weekday, the gym lighting and HVAC component of the load may be clearly seen on the weekend.

Method 2: Load Identification using Delta kW Profiles

City Hall Delta kW Load Profiles

Figure 3 shows a delta kW profile for winter hours. It doesn't show the scattering of cooling related loads that are seen when the shoulder and summer data are included as shown in Figure 4.

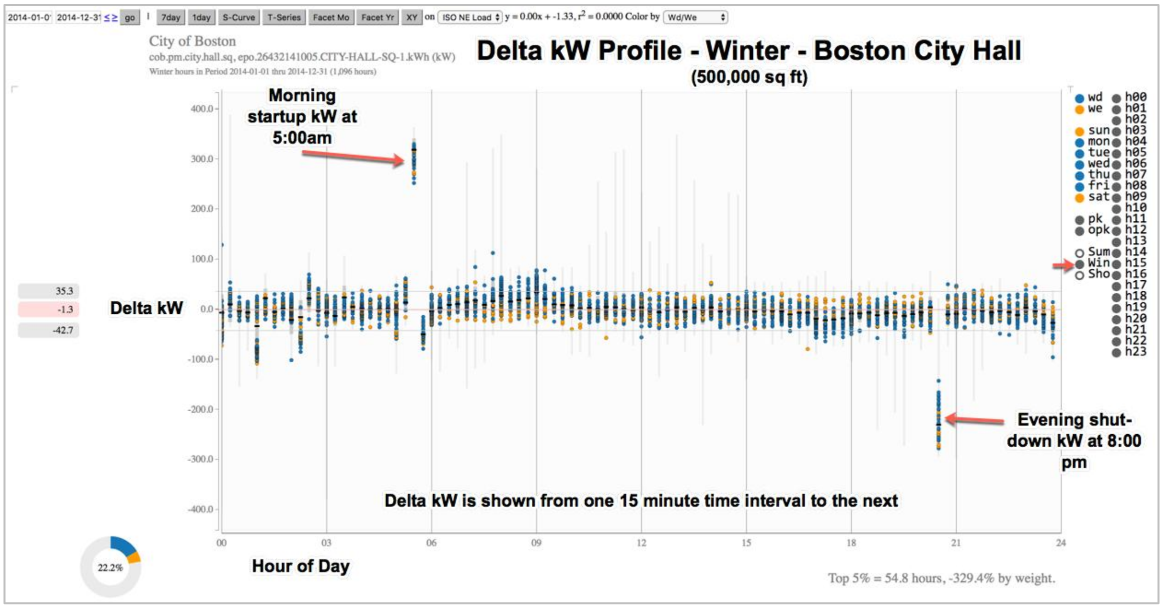

Figure 3. Delta kW for consecutive intervals for winter hours in 2014 at Boston City Hall.

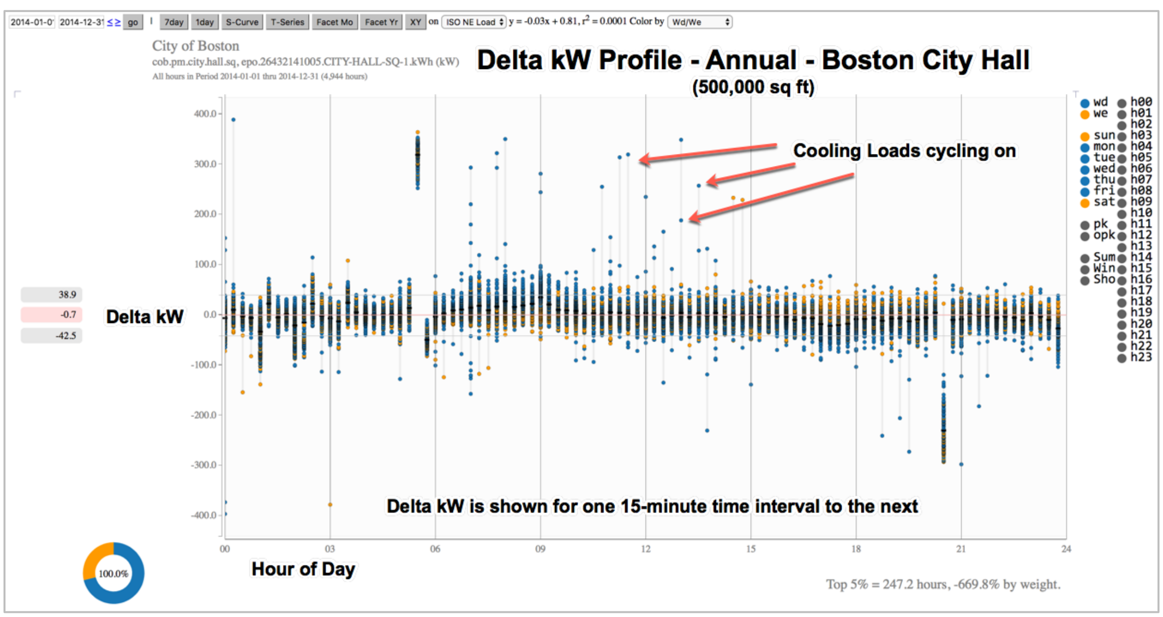

Figure 4. Delta kW for consecutive loads for all hours in 2014.

The 15-minute resolution on the above graph “dampens” the magnitude of data points related to individual cooling loads (vs. 5-minute data resolution), but gives a good indication of cooling-related costs that will show up on the electric bill as monthly demand charges and ICAP charges that may not be obvious from the monthly electric utility invoice.

Honan Allston Library Delta kW Load Profiles

Figure 5 shows winter hours for Honan Allston Library. Notice the absence of scattering of cooling-related loads compared to Figure 6 which includes the shoulder and summer hours for this 20,000 sq. ft. library.

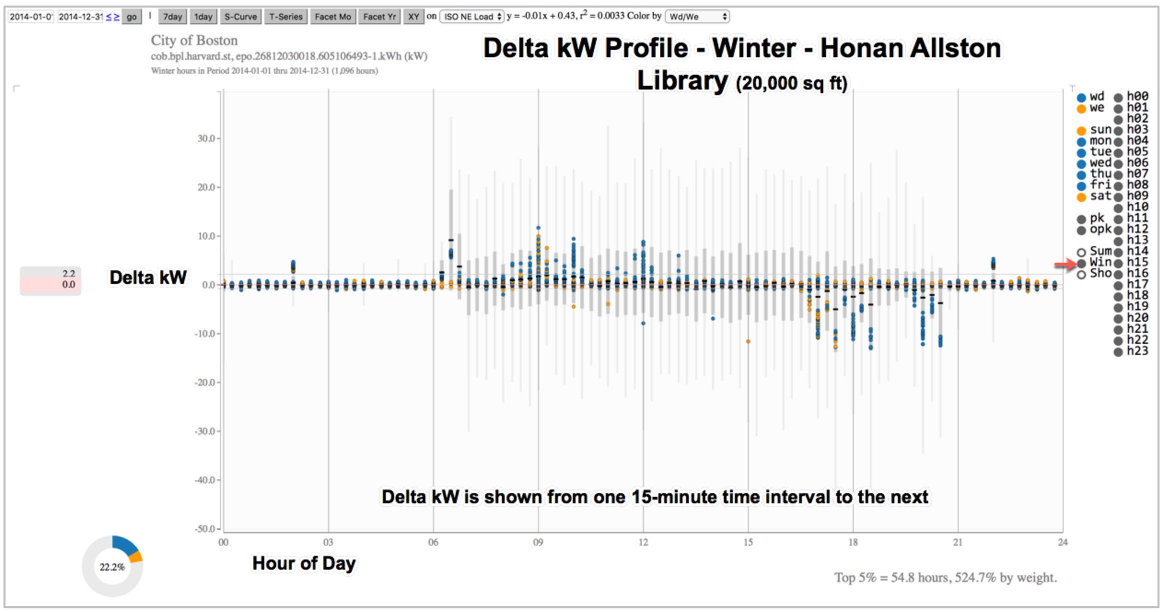

Figure 5. Delta kW of consecutive intervals for winter hours in 2014 at Honan Allston.

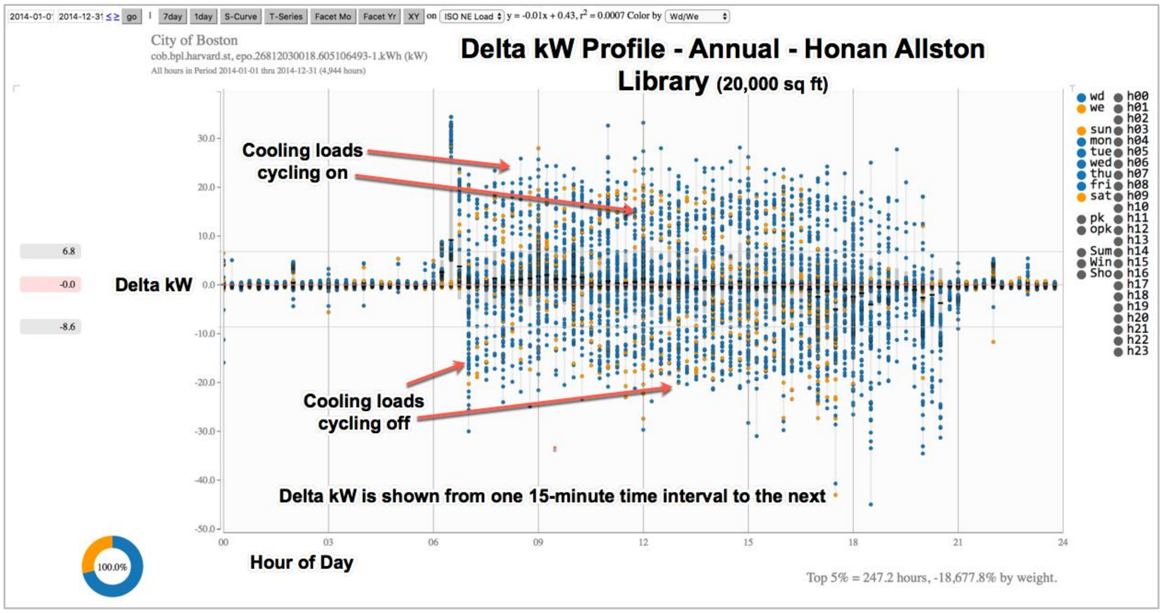

Figure 6. Delta kW of consecutive intervals for all hours in 2014 at Honan Allston.

There is a minimal amount of equipment cycling during the unoccupied summer and shoulder season hours, but the load fluctuations during the occupied hours are significant. The library may be a good application for both thermal (phase change material) and battery storage technologies to smooth out the occupied load profile. The start-up and cooling kW loads at the Honan Allston library are considerably higher than Boston City hall on a kW per sq. ft. basis.

Copley Library Delta kW Load Profiles

Figure 7 shows this 500,000 sq. ft. library operating within a narrow band of delta kW per square foot during winter 2014.

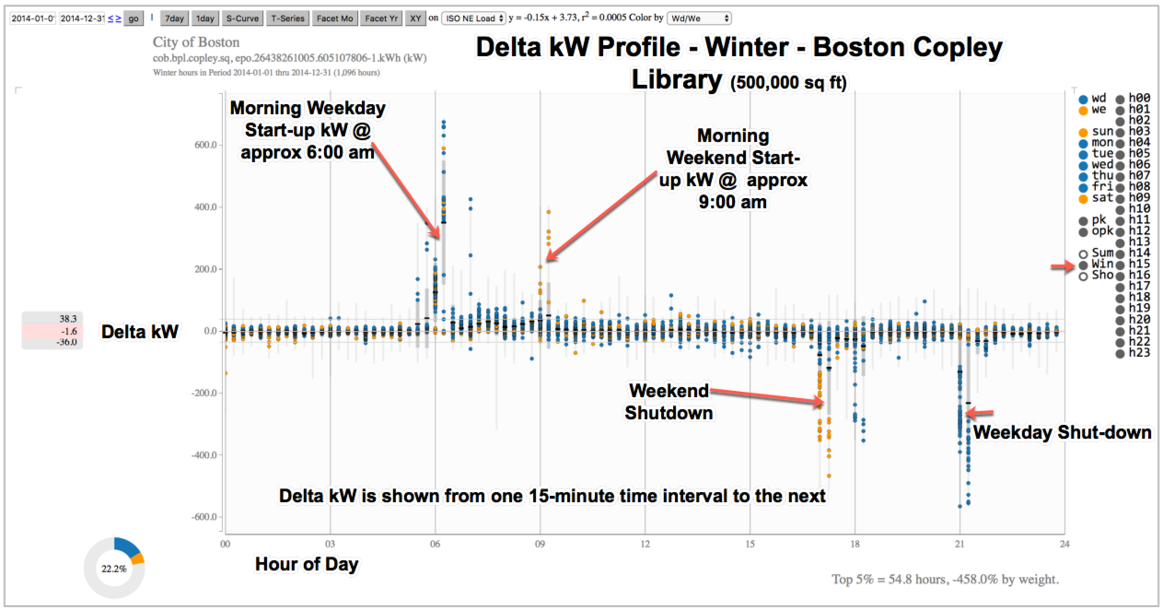

Figure 7. Delta kW of consecutive intervals for winter hours in 2014 at Boston Copley Library.

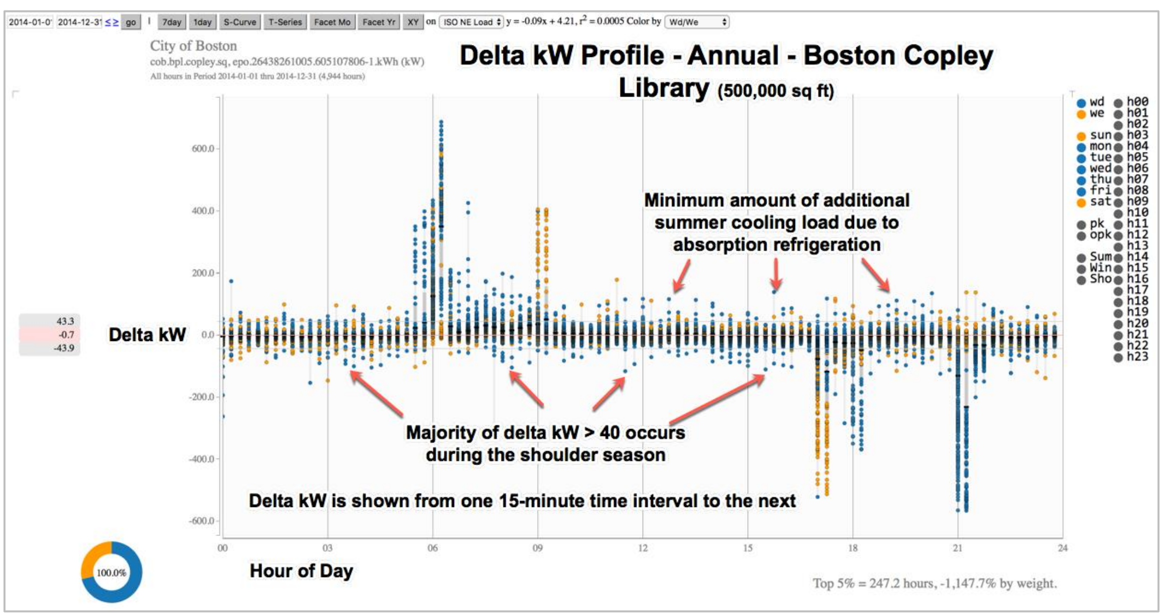

Figure 8. Delta kW of consecutive intervals for all hours in 2014 at Boston Copley Library.

When information is known about equipment schedules, the Copley Library is a good example of how a wealth of information can be discovered about discrete loads. By knowing what is not operated on weekends vs. weekdays, it is easy to identify the components of a 200 kW differential load and determine if it can be reduced on a demand response day.

The combination of interval data and the ability to filter data by hours, days and season allows the evaluation of energy consumption in buildings with the main electric meter.

Method 3: Load Identification using an Advanced Data Acquisition Solution

With an advanced data acquisition device such as the Obvius 7810, the ability to record pulses at one minute intervals and also record information regarding “rolling” groups of pulses occurring within the one-minute time period significantly improves the resolution that helps to identify significant discrete loads without the need for specialized sub-metering equipment. The rolling groups of pulses allow the calculation of minimum, maximum and instantaneous kW consumption during the one-minute time interval and this significantly increases the ability to disaggregate individual loads when we statistically evaluate the frequency of sub-minute pulse counts.